Draft
Delisting Decision
for
Big Yellow Creek

Waterbody ID AL03160112-0201-102

Metals (Pb)

Alabama Department of Environmental Management
Water Quality Branch
Water Division
January 2018

Big Yellow Creek Watershed Map in the Black Warrior River Basin

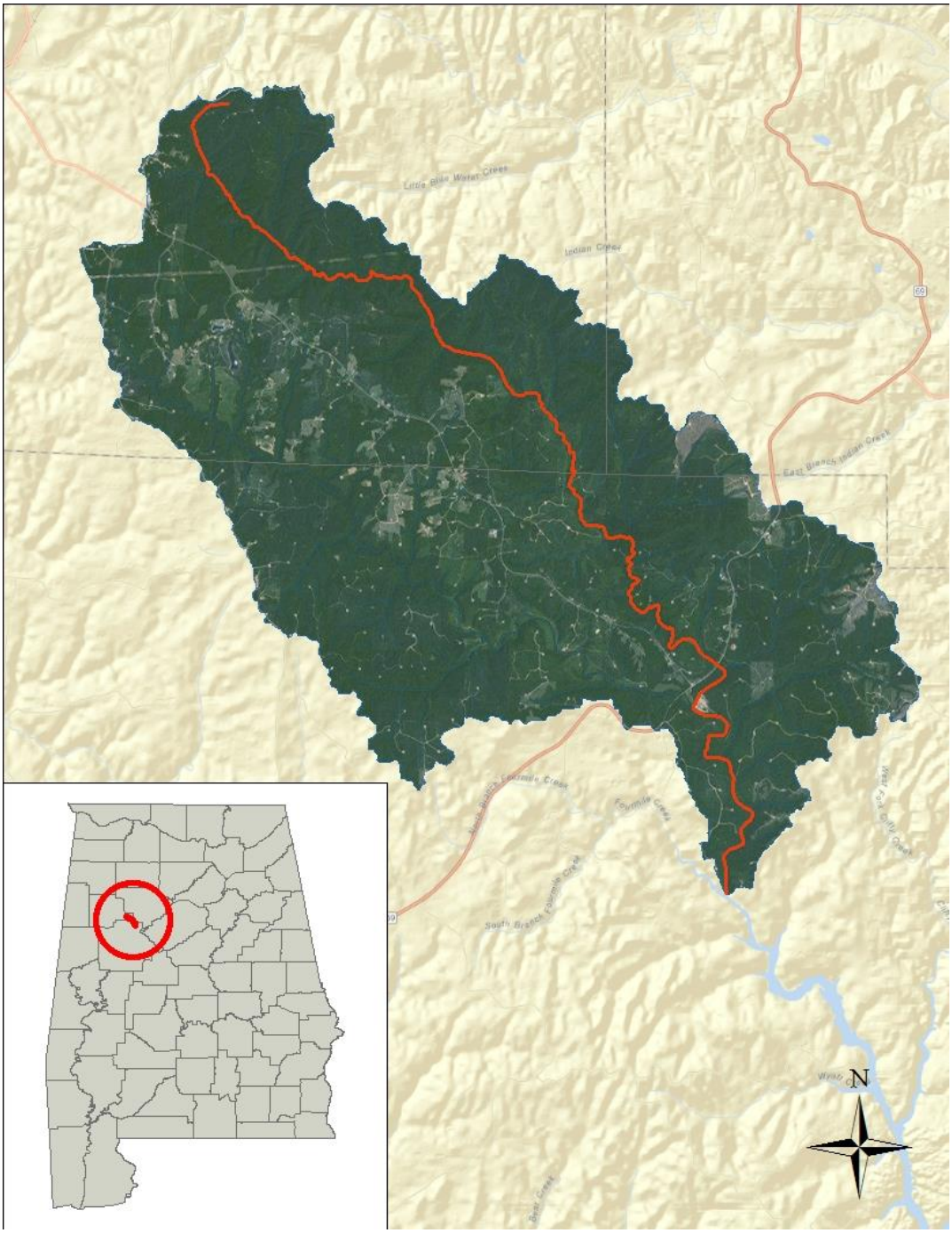


Table of Contents *Page*

List of Tables and Figures

1.0 Executive Summary

Big Yellow Creek, located in Fayette and Tuscaloosa Counties, is a part of the Black Warrior River Basin. Big Yellow Creek originates in east Fayette County, and runs southeast into Tuscaloosa County approximately twenty-three miles before draining into the Black Warrior River. Big Yellow Creek has a use classification of Fish & Wildlife (F&W) and Swimming (S).

In 1998, Big Yellow Creek was originally listed on the State of Alabama's §303(d) list for metals and pH by the Environmental Protection Agency (EPA). The 14.59 mile length of the impaired segment is from Bankhead Lake to its source. The original listing was reportedly based on data collected from 1967 through 1984 by the United States Geological Survey (USGS). The data was collected from Stations 2462470 and 12462480. Big Yellow Creek has subsequently been listed on Alabama's 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014 and 2016 §303(d) lists of impaired waterbodies.

In 2000, ADEM addressed the pH impairment by removing Big Yellow Creek from the §303(d) list. The justification for the removal was that, of 17 measurements made by ADEM between 1988 and 1999, none were outside the criteria range of 6.0 – 8.5 s.u.

In 2006, ADEM clarified the metals impairment on the §303(d) List by specifying the metals of concern were chromium and lead (Cr, Pb). This clarification was based on the chromium and lead exceedances that were observed from the 1967-1984 USGS data, on which the original 1998 listing was based. However, it should be noted that these "reported" historical exceedances for chromium and lead were based on the total phase, which is inconsistent with ADEM's water quality criteria for these metals, which are expressed in the dissolved phase. Therefore, there remains some uncertainty as to the basis of the original listing of Big Yellow Creek.

In 2012, ADEM addressed the metals (Cr) impairment by removing Big Yellow Creek from the §303(d) list. The justification for the removal was that, of seven measurements made by ADEM in 2008, it was determined that no violations of Chromium were present.

In 2014, additional data was acquired for Big Yellow Creek to assess its ability to meet applicable water quality standards. The data indicates that Big Yellow Creek, from Bankhead Lake to its source, now fully supports its use classification with respect to metals (Pb).

The following report only addresses the results of the delisting analysis of Big Yellow Creek for Lead. Based on an assessment of all available data, ADEM has determined that a water quality impairment due to metals (Pb) does not exist. Therefore, ADEM will not develop a TMDL due to "more recent or accurate data," which is just cause for delisting a waterbody according to Title 40 of the Code of Federal Regulations (CFR), Part 130.7(b)(6)(iv).

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA), as amended by the Water Quality Act of 1987 and EPA's Water Quality Planning and Management Regulations [Title 40 of the Code of Federal Regulations (CFR), Part 130], requires states to identify waterbodies which are not meeting water quality standards applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to designated use classifications. TMDLs for all pollutants causing violation of applicable water quality standards are established for each identified water. Such loads are established at levels necessary to implement the applicable water quality standards with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The 2016 §303(d) list states that Big Yellow Creek is impaired for a length of 14.59 miles from Bankhead Lake to its source and has been prioritized as a "high priority." The original listing was reportedly based on data collected from 1967 through 1984 by the United States Geological Survey (USGS). The data was collected from Stations 2462470 and 12462480. Of the metals data collected, one total chromium and three total lead samples were reported above ADEM's criteria. The chromium value was 10 µg/l and the lead values were 1 µg/L, 2 µg/L and 290 µg/l at Station 12462480. Additionally, Big Yellow Creek was monitored during the years of 1979-85 and 1988 by ADEM; however, ADEM did not sample for metals during those sampling events.

Big Yellow Creek was subsequently included in the 1998 Water Quality Report to Congress. In 1998, Big Yellow Creek was placed on the §303(d) list by EPA with the pollutants of concern being metals and pH. The basis for the original listing is the 1967-1984 USGS data. Big Yellow Creek has subsequently been listed on the 2000, 2002, 2004, 2006, 2008, 2010, 2012, 2014 and 2016 §303(d) lists of impaired waterbodies. Big Yellow Creek has a use classification of Fish & Wildlife (F&W) and Swimming (S).

In 2000, ADEM addressed the pH impairment by removing Big Yellow Creek from the §303(d) list. The justification for the removal was that, of 17 measurements made by ADEM between 1988 and 1999, none were outside the criteria range of 6.0 – 8.5 s.u.

In 2006, ADEM clarified the metals impairment on the §303(d) List by specifying the metals of concern were chromium and lead (Cr, Pb). This clarification was based on the chromium and lead exceedances that were observed from the 1967-1984 USGS data, on which the original 1998 listing was based. However, it should be noted that these "reported" historical exceedances for chromium and lead were based on the total phase, which is inconsistent with ADEM's water quality criteria for these metals, which are expressed in the dissolved phase. Therefore, there remains some uncertainty as to the basis of the original listing of Big Yellow Creek.

In 2012, ADEM addressed the metals (Cr) impairment by removing Big Yellow Creek from the §303(d) list. The justification for the removal was that, of seven measurements made by ADEM in 2008, it was determined that no violations of Chromium were present.

Table 2.1 EPA's Original Listing of Big Yellow Creek

Water Name	Location	Pollutant(s) of Concern	Priority Ranking
03160112-050 Big Yellow Creek	Tuscaloosa County	Metals (Cr, Pb) pH	High

3.0 Technical Basis for Delisting Decision

3.1 Water Quality Target Identification

According to ADEM's Water Quality Criteria (Administrative Code 335-6-10-.07), both acute and chronic aquatic life criteria and human health (consumption of fish only) criteria are applicable for waterbodies classified as Fish and Wildlife and Swimming.

Acute and chronic aquatic life criteria for most metals are hardness dependent. Hardness values must be entered into equations that are specific to each metal. These equations are provided in Appendix 6.3. Metals criteria for Big Yellow Creek were calculated using individual hardness values from each sampling event at each sampling station. Table 3.3 of Section 3.4 depicts specific water quality targets for lead at the station sampled.

3.2 Source Assessment

3.2.1 Point Sources in the Big Yellow Creek Watershed

Continuous Point Sources

Currently there are no active continuous point sources with National Pollutant Discharge Elimination System (NPDES) permits within the listed portion of the Big Yellow Creek watershed.

Non-Continuous Point Sources

The Big Yellow Creek watershed has one non-continuous point source, namely Warrior Met Coal BCE, LLC (Blue Creek Energy No. 1 Mine), which has 61 permitted stormwater outfalls (4 active & 57 proposed/inactive). This facility operates under permit number AL0081477. There are no CAFOs located in the Big Yellow Creek watershed. Currently none of the Big Yellow Creek watershed qualifies as a Municipal Separate Storm Sewer System (MS4) area.

Figure 3.1. Source Map for the Big Yellow Creek Watershed

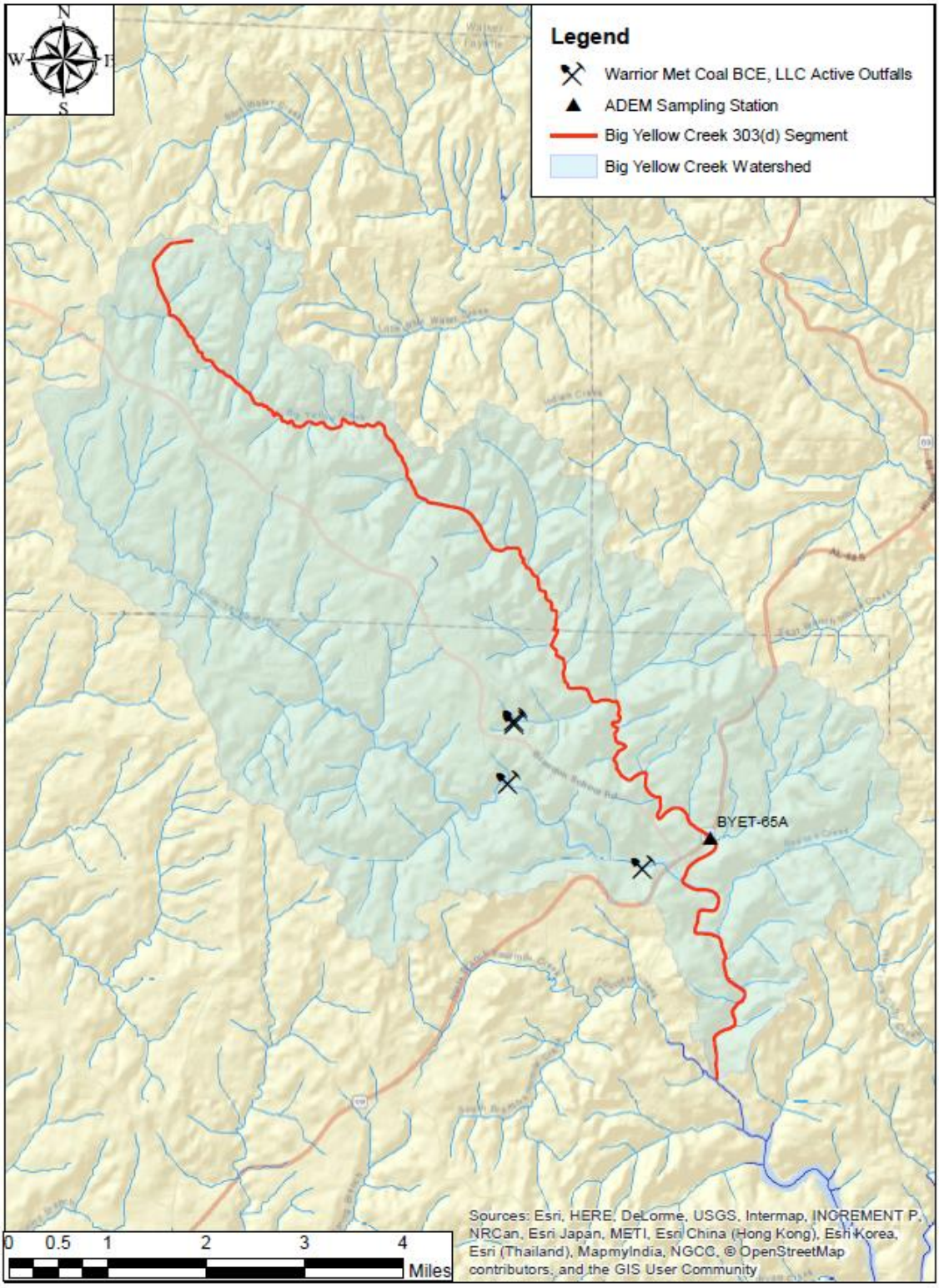


Table 3.1. Sources in the Big Yellow Creek Watershed

Name	Permit Number	Type	Major/Minor	Number of Active Outfalls
Warrior Met Coal BCE, LLC	AL0081477	Mining	Minor	4

3.2.2 Nonpoint Sources in the Big Yellow Creek Watershed

From review of the data collected on Big Yellow Creek, it is believed that nonpoint sources are not causing or contributing to any Lead issues in Big Yellow Creek.

3.3 Land Use Assessment

Land use for the Big Yellow Creek watershed was determined using ArcMap with land use datasets derived from the 2011 National Land Cover Dataset (NLCD). Figure 3.2 and Table 3.2 display the land use areas for the Big Yellow Creek watershed. Figure 3.3 is a graph depicting the primary land uses in the Big Yellow Creek watershed.

The majority of the Big Yellow Creek watershed is Forested/Natural (96.14%). The other major land uses within the watershed include Agricultural (2.24%), Developed (1.51%), and Open Water (0.10%). Developed land includes both commercial and residential land uses.

Figure 3.2. 2011 Land Use Map for the Big Yellow Creek Watershed

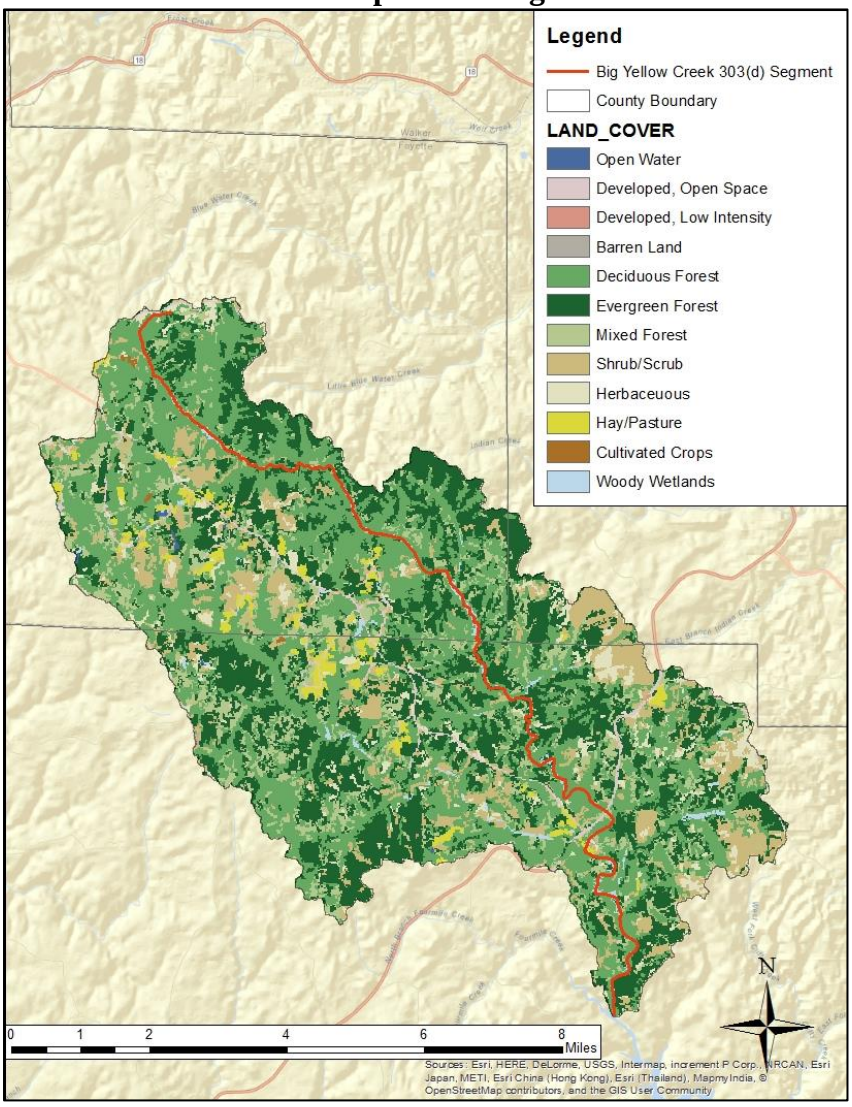
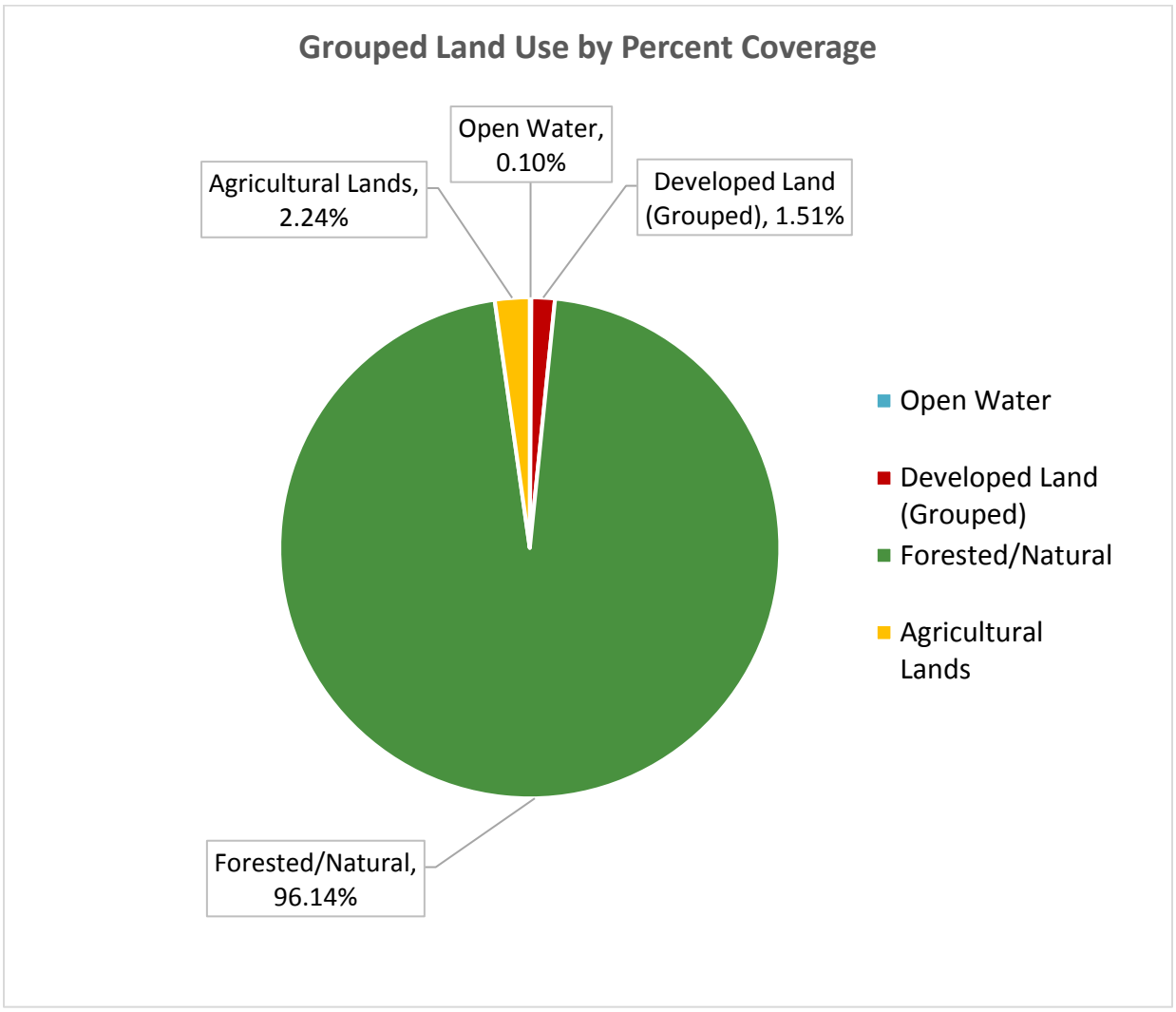


Table 3.2. Land Use Areas for the Big Yellow Creek Watershed

Class Description	Mi²	Acres	Percent
Open Water	0.034	22.02	0.10%
Agricultural Lands	0.80	510.92	2.24%
Forested / Natural	34.21	21893.87	96.14%
Developed Land (Grouped)	0.54	344.99	1.51%
TOTALS →	**35.58**	**22771.80**	**100.00%**

Figure 3.3. Graph of Primary Land Uses in the Big Yellow Creek Watershed



3.4 Data Availability and Analysis

It should be noted that even though Big Yellow Creek was sampled prior to 2014, only the data that is approximately six years in age or less and used a method detection limit below the lead criteria will be used in this analysis, which is consistent with Alabama's Water Quality Assessment and Listing Methodology (ADEM, 2016). Data collected prior to 2014 indicated that lead was below the detection limit; however, that data is inconclusive because the MDLs utilized were greater than the applicable lead criteria.

The source of data that was utilized in the evaluation of Big Yellow Creek is from ADEM's 2014 §303(d) sampling program. Both physical and chemical data were collected at the following sampling station: BYET-65A. This data can be found in Appendix 6.2. Refer to Table 3.4 for a location description of the aforementioned sampling station and to Figure 3.4 for a map depicting the location of the sampling station.

ADEM collected seven lead samples at BYET-65A, and of the seven samples there were no lead violations. Based on review of the data, ADEM has determined that no violations of lead are present. Please refer to Table 3.3 and Table 3.5 for a summary of the metals (Pb) results.

Table 3.3 Summary of Metals (Pb) Analysis for Big Yellow Creek

			Hardness Dependent
Station_ID	**Date**	**Hardness (mg/l)**	**Pb-dis [1] (µg/l)**
Criteria @ sampled hardness			**0.376**
BYET-65A	3/12/2014	**18.1**	LDL/0.117
Criteria @ sampled hardness			**0.249**
BYET-65A	4/9/2014	**12.6**	LDL/0.117
Criteria @ sampled hardness			**0.383**
BYET-65A	5/15/2014	**18.4**	LDL/0.117
Criteria @ sampled hardness			**0.308**
BYET-65A	6/11/2014	**15.18**	LDL/0.117
Criteria @ sampled hardness			**0.447**
BYET-65A	7/15/2014	**21.1**	LDL/0.117
Criteria @ sampled hardness			**0.617**
BYET-65A	8/14/2014	**28.1**	LDL/0.117
Criteria @ sampled hardness			**0.463**
BYET-65A	10/14/2014	**21.79**	0.140

1 EPA Analytical Method 200.8 used – Method Detection Limit (MDL) = 0.117 µg/L
LDL = Less than detection limit

Table 3.4 Big Yellow Creek Sampling Stations

ADEM Station	USGS Station	Latitude	Longitude	Description
BYET-65A	02462480	33.5719	-87.4028	AL Highway 69
-	02462470	33.6325	-87.4667	-

Table 3.5 Summary of 2014 Big Yellow Creek Metals (Pb) Results

Station	Metal	Total # of Samples Collected	Total # of Violations	% of Violations	Support Status
BYET-65A	Pb	7	0	0	Full

Figure 3.4. Map of Sampling Location for Big Yellow Creek

4.0 Conclusions

From examination of all available data, ADEM has determined that a water quality impairment due to metals (Pb) does not currently exist within Big Yellow Creek. Therefore, ADEM will not develop a TMDL due to "more recent data," which is a just cause for delisting waterbodies according to Title 40 of the Code of Federal Regulations (CFR), Part 130.7(b)(6)(iv).

5.0 Public Participation

As part of the public participation process, this Delisting Decision (DD) will be placed on public notice and made available for review and comment. A public notice will be prepared and published in the major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject DD will be made available on ADEM's Website: www.adem.state.al.us. The public can also request hard or electronic copies of the DD by contacting Ms. Kimberly Minton at 334-271-7826 or kminton@adem.alabama.gov. The public will be given an opportunity to review the DD and submit comments to the Department in writing. At the end of the comment period, all written comments received during the public notice period will become part of the administrative record. ADEM will consider all comments received by the public prior to final completion of this DD and subsequent submission to EPA Region 4 for final approval.

Appendix 6.1
References

ADEM Administrative Code, 2017. Water Quality Program, Chapter 335-6-10, Water Quality Criteria, and Chapter 335-6-11, Use Classifications for Interstate and Intrastate Waters.

Alabama Department of Environmental Management's §303(d) Monitoring Program. 1999, 2002, 2008, 2012, & 2014.

Alabama Department of Environmental Management (ADEM). Alabama's Water Quality Assessment and Listing Methodology, January 2016.

United States Environmental Protection Agency. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process, Office of Water, EPA 440/4-91-001.

Alabama Department of Environmental Management (ADEM). Alabama's 1998 Water Quality Report to Congress. 1998.

United States Environmental Protection Agency. Surface Water Quality Screening Assessment of the Black Warrior River Basin. January 1999.

Appendix 6.2
Water Quality Data

Data from 2014 303(d) Monthly Sampling Metals
Station BYET-65A

Station ID	Visit Date	Hardness mg/l	Cd Dis ug/l	Cd Dis dc	Cr Dis ug/l	Cr Dis dc	Cu Dis ug/l	Cu Dis dc	Pb Dis ug/l	Pb Dis dc	Ni Dis ug/l	Ni Dis dc	Zn Dis ug/l	Zn Dis dc
BYET-65A	3/12/2014	18.1	0.237	< MDL .237	0.191	< MDL .191	0.527	< MDL .527	0.117	< MDL .117	0.679	JI	1	< MDL 1
BYET-65A	4/9/2014	12.6	0.237	< MDL .237	0.191	< MDL .191	0.527	< MDL .527	0.117	< MDL .117	0.923	JI	1	< MDL 1
BYET-65A	5/15/2014	18.4	0.237	< MDL .237	0.191	< MDL .191	0.527	< MDL .527	0.117	< MDL .117	0.355	JI	1	< MDL 1
BYET-65A	6/11/2014	15.2	0.237	< MDL .237	0.191	< MDL .191	0.527	< MDL .527	0.117	< MDL .117	0.697	JI	1	< MDL 1
BYET-65A	7/15/2014	21.1	0.237	< MDL .237	0.191	< MDL .191	0.527	< MDL .527	0.117	< MDL .117	0.182	< MDL .182	1	< MDL 1, JQ2
BYET-65A	8/14/2014	28.1	0.237	< MDL .237	0.191	< MDL .191	0.649	JI	0.117	< MDL .117	0.182	< MDL .182, JQ2	1	< MDL 1
BYET-65A	10/14/2014	21.8	0.237	< MDL .237	0.561	JI	1.35	JQ6	0.14	JI	2.46	JI	19.3	

JI = The identification of the analyte is acceptable; the reported value is an estimate. The reported value is between the MDL (method detection limit) and the RL (Reporting Level).

Data from 2012 303(d) Monthly Sampling Metals
Station BYET-65A

Station ID	Visit Date	Hardness mg/l	Cd Dis ug/l	Cd Dis dc	Cr Dis ug/l	Cr Dis dc	Cu Dis ug/l	Cu Dis dc	Pb Dis ug/l	Pb Dis dc	Ni Dis ug/l	Ni Dis dc	Zn Dis ug/l	Zn Dis dc
BYET-65A	4/11/2012	20.4	0.027	JI	9	< MDL 9	20	< MDL 20	0.868	< MDL .868	42	< MDL 42	12	< MDL 12
BYET-65A	6/6/2012	24.8	0.022	< MDL .022	9	< MDL 9	20	< MDL 20	0.868	< MDL .868	42	< MDL 42	12	< MDL 12
BYET-65A	8/15/2012	21.1	0.046	< MDL .046	9	< MDL 9	20	< MDL 20	0.868	< MDL .868	42	< MDL 42	12	< MDL 12
BYET-65A	10/3/2012	26.1	0.046	< MDL .046	9	< MDL 9	20	< MDL 20	0.868	< MDL .868	42	< MDL 42	12	< MDL 12

Data from 2008 303(d) Monthly Sampling Metals
Station BYET-65A

Station ID	Visit Date	Hardness mgL	Cd Dis mgL	Cd Dis dc	Cr Dis mgL	Cr Dis dc	Cu Dis mgL	Cu Dis dc	Pb Dis µg/L	Pb Dis dc	Ni Dis mgL	Ni Dis dc	Zn Dis mgL	Zn Dis dc
BYET-65A	4/15/2008	14.3	0.002	< MDL .002,	0.002	< MDL .002,	0.007	< MDL .007,	0.5	< MDL .5,	0.002	< MDL .002,	0.017	< MDL .017,
BYET-65A	5/13/2008	15.4	0.002	< MDL .002,	0.002	< MDL .002,	0.007	< MDL .007,	0.5	< MDL .5,	0.002	< MDL .002,	0.017	< MDL .017,
BYET-65A	6/12/2008	19.4	0.002	< MDL .002,	0.002	< MDL .002,	0.007	< MDL .007,	0.5	< MDL .5,	0.002	< MDL .002,	0.017	< MDL .017,
BYET-65A	7/10/2008	21.1	0.002	< MDL .002,	0.002	< MDL .002,	0.007	< MDL .007,	0.5	< MDL .5,	0.002	< MDL .002,	0.017	< MDL .017,
BYET-65A	8/13/2008	24.6	0.002	< MDL .002,	0.002	< MDL .002,	0.007	< MDL .007,	0.5	< MDL .5,	0.002	< MDL .002,	0.017	< MDL .017,
BYET-65A	9/16/2008	22.2	0.002	< MDL .002,	0.008	< MDL .008,	0.007	< MDL .007,	0.5	< MDL .5,	0.02	< MDL .02,	0.017	< MDL .017,

BYET-65A	10/15/2008	31.3	0.002	< MDL .002,	0.008	< MDL .008,	0.007	< MDL .007,	0.5	< MDL .5,	0.02	< MDL .02,	0.017	< MDL .017,

Data from 2002 303(d) Monthly Sampling Metals
Station BYET-65A

Station ID	Visit Date	Hardness mgL	Cd Dis mgL	Cd Dis dc	Cr Dis mgL	Cr Dis dc	Cu Dis mgL	Cu Dis dc	Pb Dis µg/L	Pb Dis dc	Ni Dis mgL	Ni Dis dc	Zn Dis mgL	Zn Dis dc
BYET-65A	1/23/2002	12.1	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	2/12/2002	12.9	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	3/19/2002	13.0	0.003	< MDL .003,			0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	4/17/2002	12.8	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	5/6/2002	13.5	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	6/5/2002	15.3	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	7/1/2002	15.8	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,
BYET-65A	8/7/2002	7.96	0.003	< MDL .003,	0.015	< MDL .015,	0.02	< MDL .02,	2	< MDL 2,	0.03	< MDL .03,	0.03	< MDL .03,

Data from 1999 Monthly Sampling Metals
Station BYET-65A

Station ID	Visit Date	Hardness mgl	Cd Tot mgl	Cd Tot dc	Cr Tot mgl	Cr Tot dc	Cu Tot mgl	Cu Tot dc	Zn Tot mgl	Zn Tot Dc	Pb Tot ugl	Pb Tot dc
BYET-65A	5/13/1999		.003	< MDL .003,	.015	< MDL .015,	.02	< MDL .02,	.03	< MDL .03,	2	< MDL 2,
BYET-65A	6/23/1999		.003	< MDL .003,	.015	< MDL .015,	.02	< MDL .02,	.03	< MDL .03,	4	
BYET-65A	7/27/1999		.003	< MDL .003,	.015	< MDL .015,	.02	< MDL .02,	.03	< MDL .03,	15	
BYET-65A	8/11/1999		.003	< MDL .003,	.015	< MDL .015,	.02	< MDL .02,	.03	< MDL .03,	2	< MDL 2,

USGS Data from 1967 to 1984
Stations 2462470 and 2462480

Station	Date	Time	WATER TEMP CENT	STREAM FLOW INST-CFS	STREAM FLOW oor	PH SU	TOT KJEL N MG/L	TOT HARD CACO3 MG/L	CHROMIUMCR TOT UG/L	COPPER CU TOT UG/L	IRON FE TOT UG/L	LEAD PB TOT UG/L	LEAD PB TOT oor	MANGNESE MN UG/L	ZINC ZN TOT UG/L	SUSP SED CONC MG/L
2462470	4/10/1980	1615	17.5	5.8		6.5		7			480			60		5
2462480	3/30/1967			7.4		7.1		12								
2462480	10/26/1967	1315	12	0		6.9		25								
2462480	6/5/1979	830	21	2.96		6.9					880			50		8
2462480	8/30/1979	1300	26.5	0.81		6.7					930					2
2462480	5/23/1980	1130	17	114		6.2					910			30		26
2462480	7/17/1980	845	25	0.09		5.8		24		3	730	2		130	10	8
2462480	5/27/1981	1500	20	5.34		6.8					840			60		
2462480	2/1/1982	940	7.5	20.4		6.1	0.23	10	10	7	560	1	K	40	50	
2462480	8/24/1982	1200	25	3.16		5.7	0.8	15			720	290		50		9
2462480	10/15/1982	1245	15.5	6.02		5.6		16			940			70		
2462480	11/18/1982	1245	10	1.71	K	5.4	0.1	22			880			40		
2462480	12/16/1982	1210	10.5	139		5.2		10			1700			60		
2462480	1/19/1983	1020	2	10.8		6		11			490			60		
2462480	3/17/1983	1330	13.5	14		6.6		9			450			40		
2462480	5/19/1983	1300	17.5	2500		6.4					5200			220		
2462480	6/15/1983	1420	23	2.5		6.6					700			40		
2462480	9/15/1983	845	18	0.45		6.4					1200			70		
2462480	12/14/1983	1245	10.5			6.3					550			50		
2462480	2/15/1984	1045	8	42		4.9					450			40		

K - Analyses were transferred to another laboratory for analysis.

Appendix 6.3
Equations for calculating specific metals criteria

1. Cadmium

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(1.0166[\ln(\text{hardness in mg/l as } CaCO_3)]-3.924)}$ (CF) **(Eq. 1)**

conversion factor (CF) = 1.136672-[ln(hardness)(0.041838)]

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{(0.7409[\ln(\text{hardness in mg/l as } CaCO_3)]-4.719)}$ (CF) **(Eq. 2)**

conversion factor (CF) = 1.101672-[ln(hardness)(0.041838)]

2. Chromium (trivalent)

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(0.8190[\ln(\text{hardness in mg/l as } CaCO_3)]+3.7256)}$ (CF) **(Eq. 3)**

conversion factor (CF) = 0.316

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{(0.8190[\ln(\text{hardness in mg/l as } CaCO_3)]+0.6848)}$ (CF) **(Eq. 4)**

conversion factor (CF) = 0.860

3. Copper

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(0.9422[\ln(\text{hardness in mg/l as } CaCO_3)]-1.700)}$ (CF) **(Eq. 5)**

conversion factor (CF) = 0.960

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{(0.8545[\ln(\text{hardness in mg/l as } CaCO_3)]-1.702)}$ (CF) **(Eq. 6)**

conversion factor (CF) = 0.960

4. Lead

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(1.273[\ln(\text{hardness in mg/l as } CaCO_3)]-1.460)}$ (CF) **(Eq. 7)**

conversion factor (CF) = 1.46203-[ln(hardness)(0.145712)]

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{(1.273[\ln(\text{hardness in mg/l as } CaCO_3)]-4.705)}$ (CF) **(Eq. 8)**

conversion factor (CF) = 1.46203-[ln(hardness)(0.145712)]

5. Nickel

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(0.8460[\ln(\text{hardness in mg/l as } CaCO_3)]+2.255)}$ (CF) **(Eq. 9)**

conversion factor (CF) = 0.998

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{(0.8460[\ln(\text{hardness in mg/l as } CaCO_3)]+0.0584)}$ (CF) **(Eq. 10)**

conversion factor (CF) = 0.997

6. Pentachlorophenol

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{[1.005(pH)-4.869]}$ **(Eq. 11)**

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{[1.005(pH)-5.134]}$ **(Eq. 12)**

7. Silver

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(1.72[\ln(\text{hardness in mg/l as } CaCO_3)]-6.52)}$ (CF) **(Eq. 13)**

conversion factor (CF) = 0.85

8. Zinc

(i) freshwater acute aquatic life:

conc. (µg/l) = $e^{(0.8473[\ln(\text{hardness in mg/l as } CaCO_3)]+0.884)}$ (CF) **(Eq. 14)**

conversion factor (CF) = 0.978

(ii) freshwater chronic aquatic life:

conc. (µg/l) = $e^{(0.8473[\ln(\text{hardness in mg/l as } CaCO_3)]+0.884)}$ (CF) **(Eq. 15)**

conversion factor (CF) = 0.986

Equations for calculation of human health criteria:

(i) Consumption of water and fish:

conc. (mg/l) = (HBW x RfD x RSC)/[(FCR x BCF) + WCR] **(Eq. 16)**

(ii) Consumption of fish only:

conc. (mg/l) = (HBW x RfD x RSC)/(FCR x BCF) **(Eq. 17)**

where: HBW = human body weight, set at 70 kg

RfD = reference dose, in mg/(kg-day)

FCR = fish consumption rate, set at 0.030 kg/day

BCF = bioconcentration factor, in l/kg

WCR = water consumption rate, set at 2 l/day